Power analysis

Goal: Compare the power of different monitoring designs to detect trends in statewide average Hg concentration in largemouth bass from California lakes and reservoirs

Approach

- Difficult to determine power analytically, used a Monte Carlo approach
  - Use parameters from existing data to run simulations
  - Impose a trend on the data
  - Test our ability to detect that trend
- Consulted with Don Stevens
- Developed code in R

Data

- Used 2007-2008 SWAMP monitoring data to determine fish mercury distributions for each lake
  - Largemouth bass only
  - 350mm size standardized
- Assumed a lognormal distribution of fish Hg within a lake
- Randomly sampled fish from that lognormal distribution

Input parameters

- Number of fish sampled per lake
- Number of lakes sampled per year
- Length (in years) of sampling period
- Frequency of sampling (annual, biennial, etc)
- Regional trend
- Magnitude of inter-annual variation within a lake (unrelated to regional trend)

Choosing lakes sampled per year

- Two approaches:
  - Random sampling each year (with replacement)
  - Sample in rotating panels
    - Randomly assigning lakes to panels
    - Allowed lakes to be sampled more evenly.

Trends

- Trends based on based on patterns seen in other regions (0.004-0.016 ppm/yr).
  - Either as a constant value
  - Or as a distribution around that value that varied by lake

Calculating power

- Two models:
  - Simple linear regression of the Hg concentration by year
  - Linear model that accounted for lake effect.
- Ran simulation 1000 times, counted the number of times a significant trend was detected
- Compared scenarios by comparing the length of time needed to detect a trend with at least 0.80 power

Results - Scenario Comparisons

- Sampling 10 fish per lake
- 30 lakes per year
- Regional increase of **0.008 ppm/yr**
- Comparing 2 models and 2 lake sampling methods
- How long (years) will it take to detect a trend?

Lake Sampling Design	Statistical Analysis	Years to Detect a Trend	
		Annual Sampling	Biennial Sampling
Random sampling with replacement	Simple regression	22 yrs	28 yrs
Panel design	Simple regression	17 yrs	22 yrs
Random sampling with replacement	Regression with lake effect	10 yrs	14 yrs
Panel design	Regression with lake effect	9 yrs	12 yrs

Results - Scenario Comparisons

- Sample10 fish per lake
- Sample 30 lakes per year
- Panel design and linear model with lake effect
- How long (years) will it take to detect a regional increase of different magnitudes?

	Years to Detect a Trend	
	Annual Sampling	Biennial Sampling
Increase of 0.016 ppm/yr	7 yrs	10 yrs
Increase of 0.008 ppm/yr	9 yrs	12 yrs
Increase of 0.004 ppm/yr	16 yrs	20 yrs

Results - Scenario Comparisons

- Sample 10 fish per lake
- Sample 30 lakes per year
- Panel design and linear model with lake effect
- Adding trend as a constant vs a distribution that varies by lake
- How long (years) will it take to detect a regional increase of **0.008 ppm/yr**?

	Method for adding trend into model		
	Constant trend among lakes (0.008ppm/yr)	Distribution of trends among lakes (0.008 +/- 0.002 ppm/yr increase)	Distribution of trends among lakes (0.008 +/- 0.1 ppm /yr increase)
Annual Sampling	9 yrs	10 yrs	14 yrs
Biennial Sampling	12 yrs	12 yrs	20 yrs

Results - Scenario Comparisons

- Sample 30 lakes per year
- Panel design and linear model with lake effect
- Variable number of fish per lake
- How long (years) will it take to detect a regional increase of **0.008 ppm/yr**?

	Number of Fish per Lake			
	10	12	15	20
Annual Sampling	9 yrs	9 yrs	9 yrs	8 yrs
Biennial Sampling	12 yrs	12 yrs	12 yrs	10 yrs

Results - Scenario Comparisons

- Sampling 10 fish per lake…
- Variable number of lakes per year…
- Random sampling and linear model with lake effect…
- How long (years) will it take to detect a regional increase of **0.008 ppm/yr**?

	Number of Lakes per Year			
	20	**30**	**40**	**50**
Annual Sampling	13 yrs	10 yrs	9 yrs	8 yrs
Biennial Sampling	18 yrs	14 yrs	14 yrs	12 yrs

Summary

- Can detect realistic trends in regional Hg bioaccumulation in a reasonable timeframe
- Biennial sampling may be more cost effective
- Power was greatest when using a panel design for site selection and when accounting for lake effects in the statistical analysis.
- Power could be improved by increasing either the number of fish sampled per lake or the number of lakes sampled per year